2.1

# What Is Matter?

**KEY TERMS**

chemistry
matter
element
atom
compound
molecule
chemical formula
pure substance
mixture
miscible
immiscible

**OBJECTIVES**

- Explain the relationship between matter, atoms, and elements.
- Distinguish between elements and compounds.
- Interpret and write some common chemical formulas.
- Categorize materials as pure substances or mixtures.

Making glass, as shown in **Figure 2-1,** involves changing the raw materials sand, limestone, and soda ash into a different substance. This is what **chemistry** is all about: what things are made of and how things change. Everything you use daily, from soap to food to glue, you choose because of chemistry—either because of what it is made of or how it changes.

**chemistry** the study of matter and how it changes

Glass is used as a building material because its properties of being transparent, solid, and waterproof match the needs we have for windows. The properties of sand, on the other hand, do not match these needs. Chemistry keeps the choices among so many materials from being too confusing because it helps you recognize how the differences in material properties relate to what the materials are made of.

## Matter

**matter** anything that has mass and occupies space

You are made of **matter**. This book is also matter. All the materials you can hold or touch are matter. The air you are breathing is matter, even though you can't see it. Light, sound, and electricity are not matter. Unlike air, they have no mass or volume.

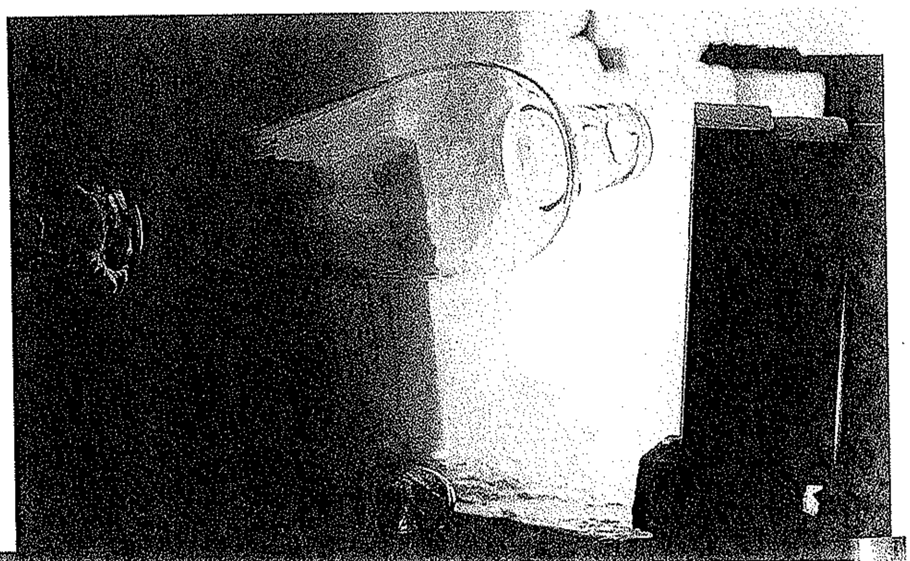


***Figure 2-1***
Glass blowers have been practicing their craft with few changes for more than 2000 years.

### Atoms are matter

Wood is matter. Because it is fairly rigid and lightweight, wood is a good choice for furniture and buildings. When wood gets hot enough, it chars—its surface turns black. The wood surface breaks down to form another kind of material with different properties, carbon. Nothing you can do to the carbon in the charred residue will cause the carbon to decompose. Carbon is an **element**, and elements are made of **atoms**. An image of some iron atoms is shown in **Figure 2-2.**

Diamonds are made of atoms of the element carbon. The shiny foil wrapped around a baked potato is made of atoms of the element aluminum. The elements that are most abundant on Earth and most abundant in the human body are shown in **Figure 2-3.** Each element also has a one- or two-letter symbol used worldwide to designate it. For example, carbon is C, iron is Fe, copper is Cu, and aluminum is Al. Each of the more than 110 elements that we now know is unique and behaves differently from the rest.

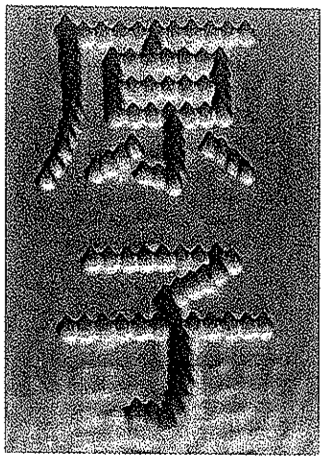


***Figure 2-2***
This scanning tunneling microscope image shows iron atoms (red) on copper atoms (blue).

**element** a substance that cannot be broken down into simpler substances

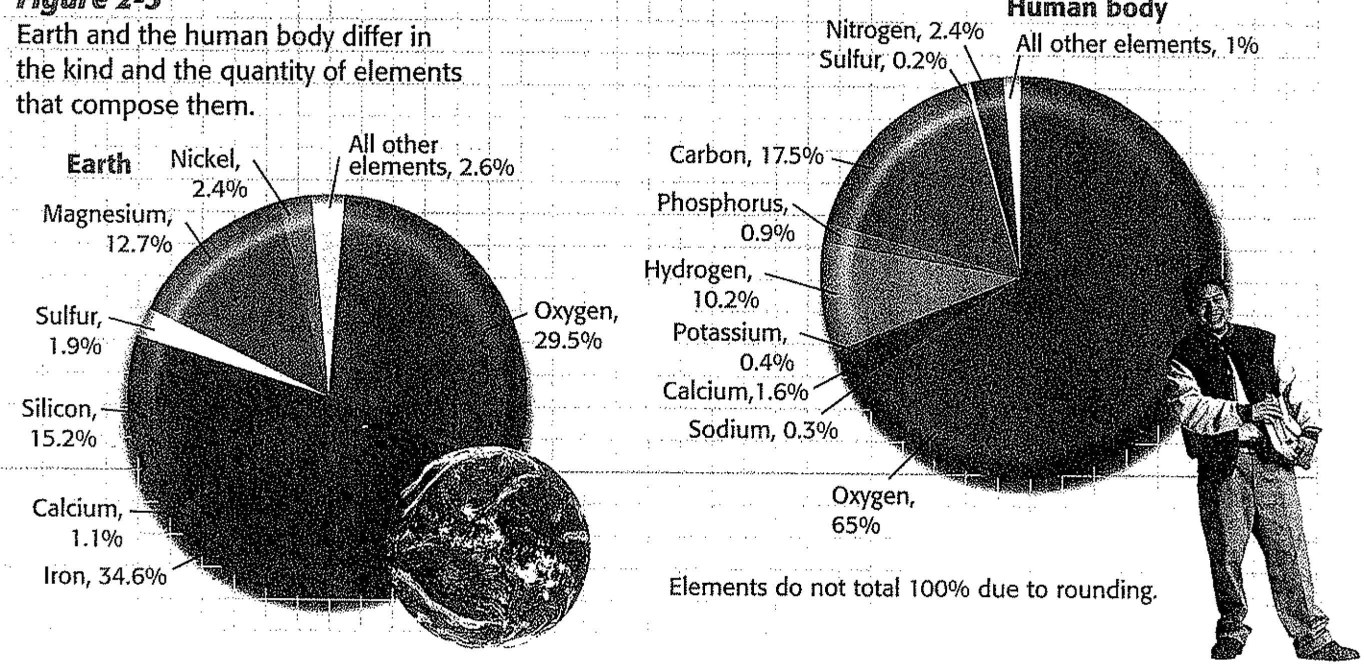
**atom** the smallest particle that has the properties of an element

**compound** a substance made of atoms of more than one element bound together

### Two or more elements combine chemically to make a compound

Many familiar substances, such as aluminum and iron, are elements. Nylon is another familiar substance, but it is not an element. Nylon is a **compound**. The basic unit that makes up nylon contains carbon, hydrogen, nitrogen, and oxygen atoms, but each strand actually contains hundreds of these units linked together.

***Figure 2-3***
Earth and the human body differ in the kind and the quantity of elements that compose them.




Elements do not total 100% due to rounding.

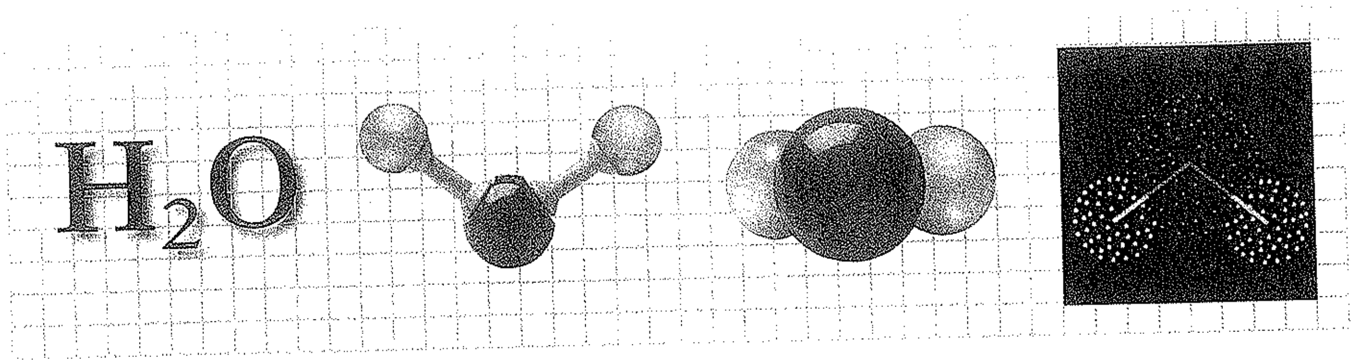



***Figure 2-4***
A water molecule can be represented as a formula, in physical models, or on a computer.

Every compound is unique and is different from the elements it contains. For example, the elements hydrogen, oxygen, and nitrogen occur in nature as colorless gases. Yet when they combine with carbon to form nylon, the strands of nylon are a flexible solid.

Each unit of iron(III) oxide, which we see often as rust, is made of two atoms of iron and three atoms of oxygen. When elements combine to make a specific compound, the elements always combine in the same proportions. Iron(III) oxide always has two parts of iron for every three parts of oxygen.

**molecule** the smallest unit of a substance that exhibits all of the properties characteristic of that substance

### A molecule acts as a unit

Atoms can join together to make millions of different **molecules** just as letters of the alphabet combine to form different words. A molecular substance you are familiar with is water. A water molecule is made of two hydrogen atoms and one oxygen atom, as shown in **Figure 2-4.**

When oxygen and hydrogen form a molecule of water, the atoms combine and act as a unit. That is what a molecule is—the smallest unit of a substance that behaves like the substance. Most molecules are made of atoms of different elements, just as water is. But a molecule also may be made of atoms of the same element, such as those in **Figure 2-5.** Besides the elements shown in the figure, fluorine, nitrogen, iodine, and bromine form molecules of two atoms. Sulfur forms a molecule of eight atoms, $S_8$.

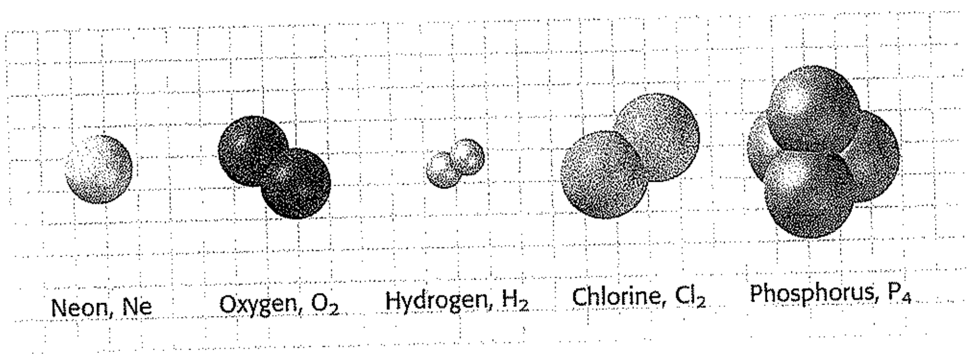
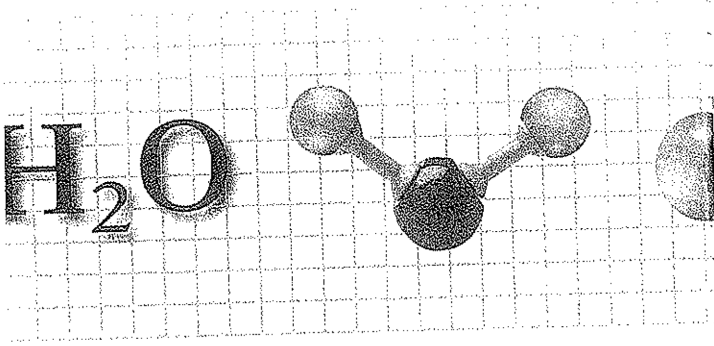



***Figure 2-5***
The atoms of most elements, such as neon, Ne, are found singly in nature. The atoms of some elements form molecules, such as oxygen, $O_2$, hydrogen, $H_2$, chlorine, $Cl_2$, and phosphorus, $P_4$.

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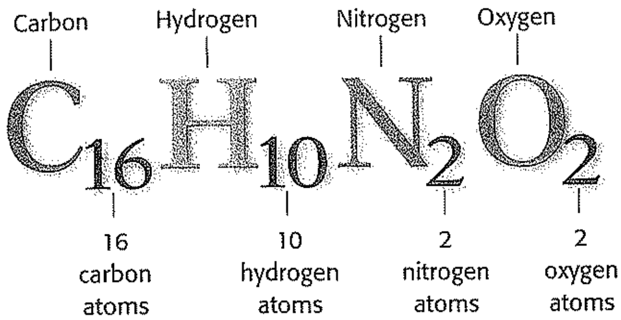


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**Figure 2-6**
The chemical formula for a molecule of indigo shows that it is made of four elements and 30 atoms.

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**chemical formula** the chemical symbols and numbers indicating the atoms contained in the basic unit of a substance

**pure substance** any matter that has a fixed composition and definite properties

**mixture** a combination of more than one pure substance

**nolecule** the smallest unit of a substance that exhibits all of the properties characteristic of that substance

**A molecule acts as a u**ntains only the juice of
Atoms can join togethe In chemistry, the word
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**INTEGRATING**

**BIOLOGY**

Indigo is a natural plant dye made from members of the genus *Indigofera,* which is in the pea family. Before synthetic dyes were developed, indigo was widely grown in the East Indies, in India, and in the Americas. Most indigo species are shrubs 1 to 2 m in height. Leaves and branches of the plants are fermented to yield a paste, which is formed into blocks and then finely ground. The blue color develops as the material is exposed to air.

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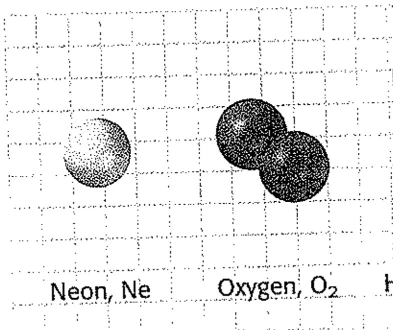
phosphorus, $P_4$.




**mixtures**
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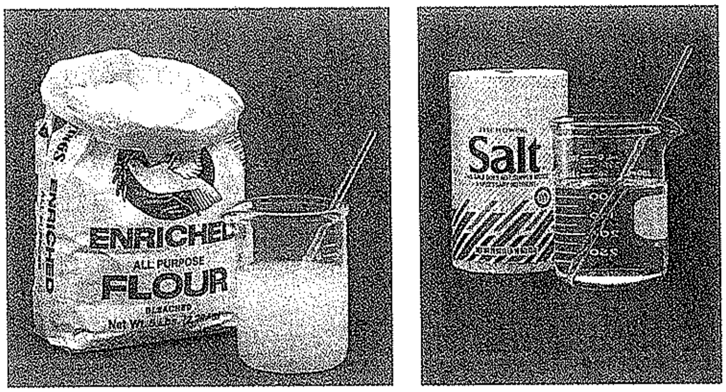
*Figure 2-7*




**A** Flour is suspended in water.  **B** Salt dissolves in water.

## Mixtures are classified by how thoroughly the substances mix

Some mixtures are made by putting solids and liquids together. In **Figure 2-7,** two white powdery solids, flour and salt, are each mixed with water. Despite the physical similarities of these solids, the mixtures they form with water are very different.

The flour doesn't mix well with the water, yielding a cloudy white mixture. You can see that flour does not dissolve in water. A mixture of flour and water is called a *heterogeneous mixture* because the substances aren't uniformly mixed.

The salt-and-water mixture looks very different from the flour-and-water mixture. You cannot see the salt, and the mixture is clear. That's because salt dissolves in water. Even if you leave the mixture for a long time, the salt will not settle out. Salt and water yield a *homogeneous mixture* because the mixing occurs between the individual units and is the same throughout.

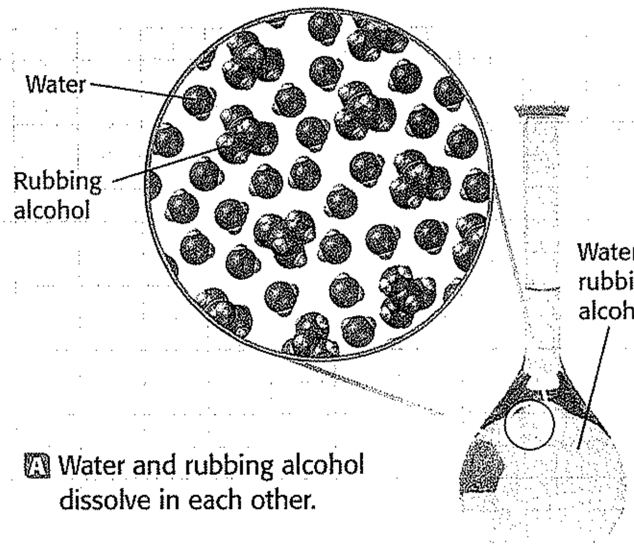
Gasoline is a liquid mixture—a homogeneous mixture of at least 100 compounds in various quantities. Because the compounds are **miscible**, gasoline looks like a pure substance even though it isn't.

If you shake a mixture of oil and water, the water will settle out after a while. Oil and water form a heterogeneous mixture. Because oil and water are **immiscible**, you can see two layers in the mixture. **Figure 2-8** shows examples of liquid mixtures.

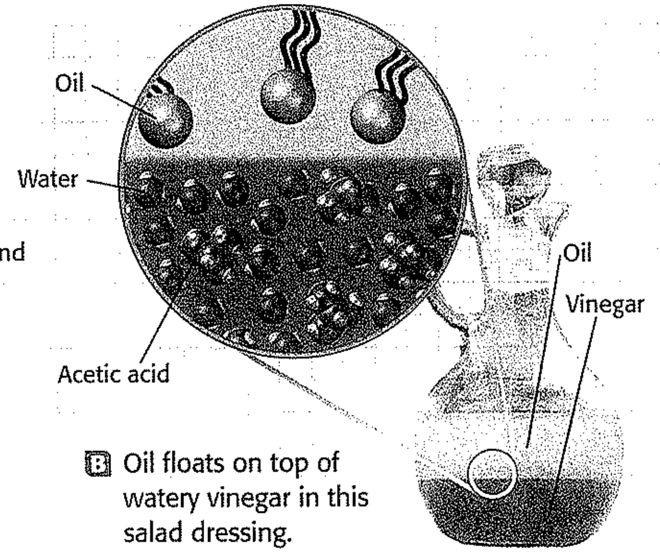
**miscible** describes two or more liquids that are able to dissolve into each other in various proportions

**immiscible** describes two or more liquids that do not mix into each other

***Figure 2-8*** **Examples of Miscible and Immiscible Liquids**




**A** Water and rubbing alcohol dissolve in each other.




**B** Oil floats on top of watery vinegar in this salad dressing.

# Science and the Consumer

## Dry Cleaning: How Are Stains Dissolved?

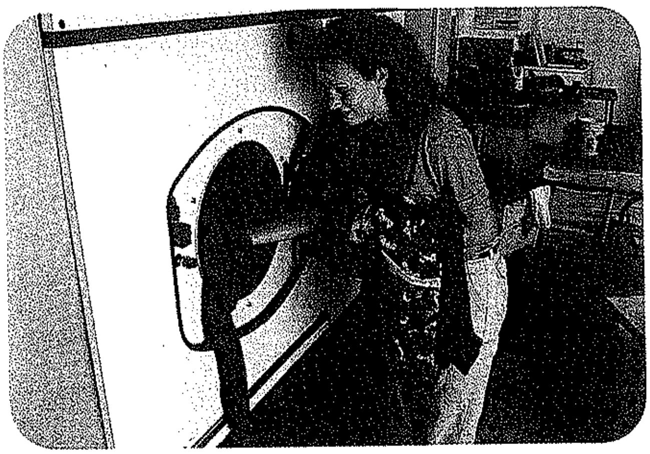
Why do some clothes need to be dry cleaned, while others do not? Washing with water and detergents cleans most clothes. But if your clothes have a stubborn stain—such as ink or rust, if you have spilled something greasy on your clothes, or if the label on the clothing recommends dry cleaning, then dry cleaning may be necessary. Dry cleaning is recommended on a clothing label when the fabric does not respond well to water. Certain fabrics, like silk and wool, are usually cleaned without water because water causes them to shrink, take on stubborn wrinkles, or lose their shape.

### Stain Removal

Knowing the composition of a stain helps dry cleaners decide how to treat it. Removing a stain that doesn't dissolve in water, such as oil or grease, involves two steps. First, the stain is treated with a substance that loosens the stain. Then the stain is removed when the garment is washed in a mechanical dry cleaner.

If a stain is water-soluble, it will dissolve in water. A water-soluble stain is first treated with a stain remover that is specific to that stain. The stain is then flushed away with a steam gun. After the garment is dry, it is cleaned in a dry-cleaning machine to remove any stains that do not dissolve in water.

**Once the fabric has been treated for tough stains, the garment is washed in a dry-cleaning machine.**



### Dry Cleaning Isn't Really Dry

In spite of its name, dry cleaning does involve liquids. The process uses a liquid solvent instead of water. It is always difficult to remove fats, greases, and oils from fabrics with water-based washing.

A good dry-cleaning solvent must dissolve oil and grease, which trap the water-insoluble particles in the cloth fibers. The most commonly used dry-cleaning solvent is tetrachloroethylene, $C_2Cl_4$. Tetrachloroethylene is the preferred solvent because oil, grease, and alcohols dissolve in it. Also, tetrachloroethylene is not flammable, and it evaporates easily. This allows it to be recycled by distillation.

In distillation, the components of a mixture are separated based on their rates of evaporation. Upon heating, the component that evaporates most quickly is the first to vaporize and separate from the mixture. When the vapors are cooled, they condense to form a purified sample of that component.

Tetrachloroethylene is suspected of causing some kinds of cancer. To meet the standards of the United States Occupational Safety and Health Administration (OSHA) and other federal guidelines, dry-cleaning machines must be airtight so that no $C_2Cl_4$ escapes.

### Your Choice

1. **Critical Thinking** Explain why it is difficult to remove fats, greases, and oils from fabrics with water-based washing alone.
2. **Critical Thinking** Tetrachloroethylene evaporates more quickly than the fats, grease, and oils it dissolves. Describe how $C_2Cl_4$ can be recycled by distillation.

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**INTEGRATING**

**EARTH SCIENCE**

The molten rock in some types of volcanoes contains large quantities of gas. Pumice, a solid foam that occurs naturally on Earth, is a volcanic rock formed by the violent separation of these extremely hot gases from lava. As the exploding lava cools, it traps the gas bubbles. Some pumice is so soft that it is spongy, and some is so light that it floats on water. Often pumice occurs as small pea-size lumps, but it also occurs in deposits large enough to be mined and sold commercially as an abrasive.

### Gases can mix with liquids

Air is a mixture of gases consisting mostly of nitrogen and oxygen. You get oxygen every time you breathe because the gases in air form a homogeneous mixture. Carbonated drinks are also homogeneous mixtures. They contain sugar, flavorings, and carbon dioxide gas, $CO_2$, dissolved in water. When carbonated drinks are manufactured, the carbon dioxide gas is mixed into the liquid under pressure and forms a solution.

Even a liquid that is not mixed with gas under pressure can contain dissolved gases. If you let a glass of cold water stand overnight, you may be able to see bubbles on the sides of the glass the next morning. The bubbles are some of the air that was dissolved in the cold water.

Carbonated drinks often have a foam on top. A foam is a different kind of gas-liquid mixture. The gas is not dissolved in the liquid but has formed tiny bubbles in it. Eventually, the tiny bubbles join together to form bigger bubbles that can escape from the foam, and the foam collapses.

Other foams are stable and last for a long time. If you whip egg white with enough air, you get a foam. If you heat that foam in an oven, the liquid egg white dries and hardens, and you have a solid foam—meringue.

## SECTION 2.1 REVIEW

### SUMMARY

- Matter has mass and occupies space.
- An element is a substance that cannot be broken down into a simpler substance.
- An atom is the smallest particle of matter that has the properties of a particular element.
- Atoms can join together to form molecules.
- A pure substance that contains two or more elements is a compound.
- A pure substance can be represented by a chemical formula.

### CHECK YOUR UNDERSTANDING

1. **Define** *chemistry.*
2. **List** the two types of pure substances.
3. **Explain** why light is not matter.
4. **Complete** the following analogy:
   A heterogeneous mixture is to a homogeneous mixture as immiscible liquids are to __________.
5. **Classify** each of the following as an element or a compound:
   **a.** sulfur, $S_8$ **c.** carbon monoxide, CO
   **b.** methane, $CH_4$ **d.** cobalt, Co
6. **Describe** the makeup of pure water, and write its chemical formula.
7. **Compare and Contrast** mixtures and pure substances. Give an example of each.
8. **Critical Thinking** David and Susan are looking at a jar of honey labeled "Pure Honey." David says, "That means it's natural honey, with nothing else added." Susan says, "It isn't really pure. It's a mixture of lots of different substances." Who is right? Explain your answer. **WRITING SKILL**

2.2

# Matter and Energy

**OBJECTIVES**

- Use the kinetic theory to describe the properties and structures of the different states of matter.
- Describe the energy transfers involved in changes of state.
- Describe the laws of conservation of mass and conservation of energy, and explain how they apply to changes of state.

**KEY TERMS**

pressure
viscosity
energy
evaporation
condensation
sublimation

If you go to a bakery, such as the one in **Figure 2-9**, you can smell the cookies baking even though you are a long way from the oven. One way to explain this phenomenon is to make some assumptions. First, assume that the particles (molecules and atoms) within substances can move. Second, assume that the molecules and atoms move faster as the temperature rises. A theory based on these assumptions, called the kinetic theory of matter, can be used to explain things like why you can smell cookies baking from far away.

When cookies are baking, energy is transferred from the oven to the cookies. As the temperature in the oven is increased, some molecules within the cookie dough move fast enough to become gases, which in turn spread through the air in the bakery.

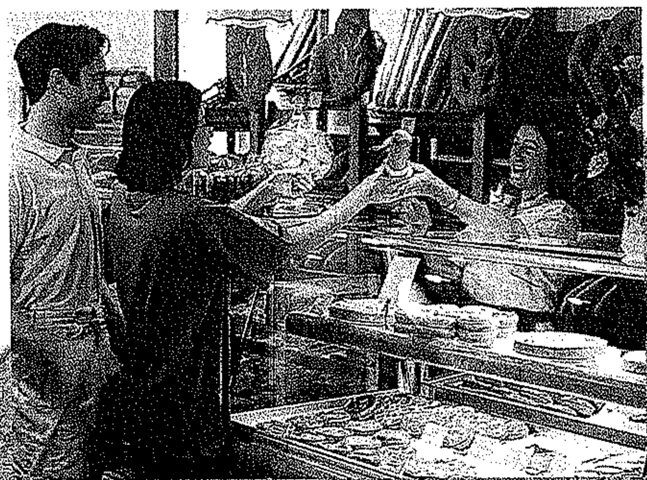


***Figure 2-9***
The substances that make the fresh cookies smell so good may be vanillin, $C_8H_8O_3$, or cinnamaldehyde, $C_9H_8O$.

## Kinetic Theory

Here are the main points of the kinetic theory of matter.

- **All matter is made of atoms and molecules that act like tiny particles.**
- **These tiny particles are always in motion. The higher the temperature, the faster the particles move.**
- **At the same temperature, more massive (heavier) particles move slower than less massive (lighter) particles.**

The kinetic theory is a useful tool for visualizing the differences between the three common states of matter: solids, liquids, and gases.

Common States of Matter

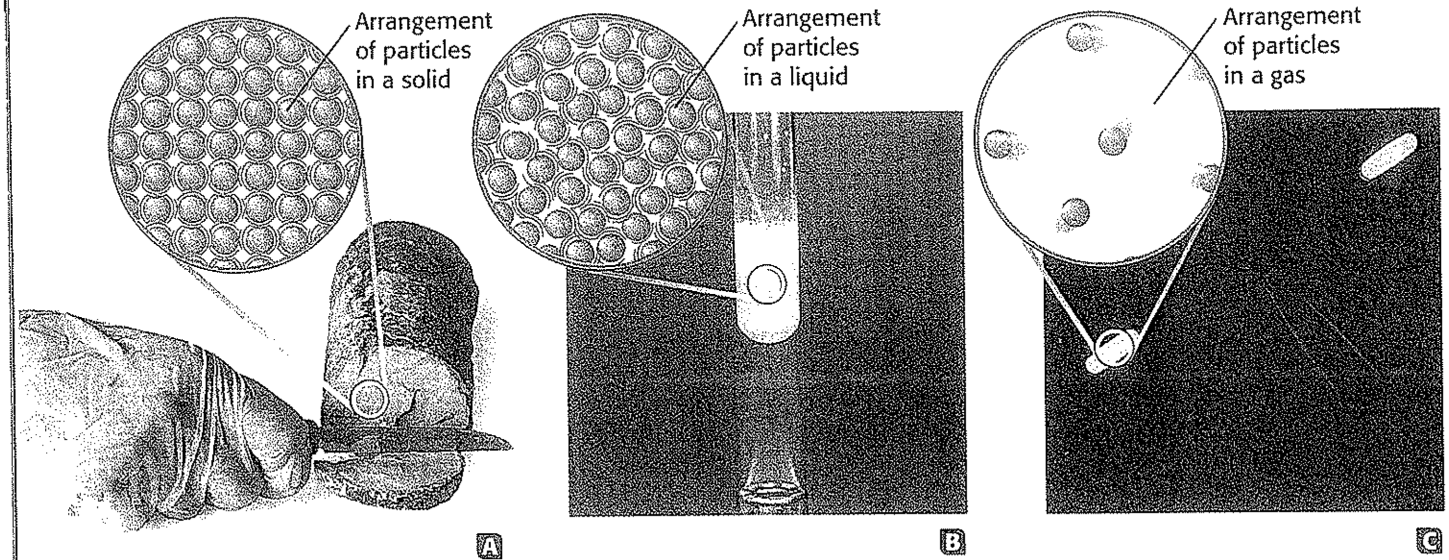



*Figure 2-10*
Gases, liquids, and solids are the most common states of matter on Earth. Here, the element sodium is shown as (A) the solid metal, (B) melted as a liquid, and (C) as a gas in a sodium-vapor lamp.

### The states of matter are physically different

The models for solids, liquids, and gases shown in **Figure 2-10** differ in the distances and angles between molecules or atoms and in how closely these particles are packed together. Gas particles, like those in helium, are in a constant state of motion and rarely stick together. In a liquid, like cooking oil, the particles are closely packed, but they can still slide past each other. Particles in a solid, like iron, are in fixed positions. Most matter found naturally on Earth is either a solid, a liquid, or a gas, but matter also exists in other states.

### Did You Know?

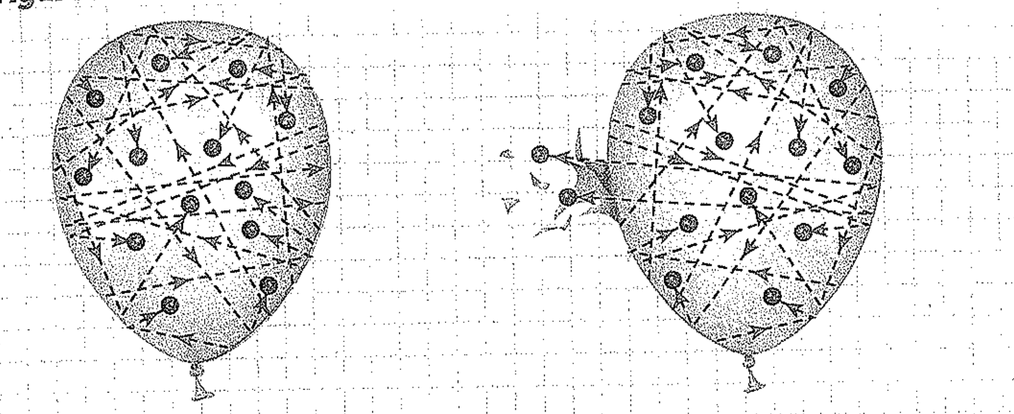
Very dense neutron stars and plasmas are examples of two other generally accepted states of matter. Our sun and most stars are plasmas made of fast-moving charged particles. In the Bose-Einstein condensate, atoms are at temperatures so close to absolute zero that they behave as one atom. This state of matter was first observed in 1995. Einstein predicted it in 1925 when he furthered the calculations of S. N. Bose, an Indian physicist.

### Gases are free to spread in all directions

Have you noticed that a balloon filled with a "light" gas such as helium goes flat more quickly than a balloon filled with air? You can use the kinetic theory to explain this. The wall of the balloon has tiny holes through which gas particles can escape. The helium particles are smaller and less massive than the nitrogen and oxygen particles found in air. The smaller and less massive particles move faster, so they get through the holes more quickly.

When you inflate a balloon, the entire balloon expands. This is one of the characteristics of a gas—it expands to fill the available space. Kinetic theory can be used to explain this property as well. Under standard conditions of temperature and pressure, particles of a gas move rapidly. Oxygen, $O_2$, averages almost 500 m/s, and helium, He, travels at more than 1200 m/s. At these speeds, gas particles collide billions of times a second. Like all particles of gas, helium atoms bounce off each other when they collide. As helium atoms bounce around and move freely, they spread to fill the available space.

*Figure 2-11*



Ⓐ Gas particles exert pressure by hitting the walls of a balloon.

Ⓑ The balloon pops because the internal pressure is more than the balloon can hold.

**Gases can exert pressure**

You may know that a balloon filled with helium is under **pressure**. The gas in the balloon is pushing out against the balloon walls. The kinetic theory also helps to explain pressure. Helium atoms in the balloon are moving very quickly and are constantly hitting each other and the walls of the balloon, as shown in the model in **Figure 2-11.** Each particle's effect on the balloon wall is tiny, but the battering by millions of particles adds up to a steady force. The pressure inside the balloon is the measure of this steady force. If too many particles of gas are in the balloon, the battering overcomes the force of the balloon holding the gas in, and the balloon pops.

**pressure** the force exerted on a unit area of a surface

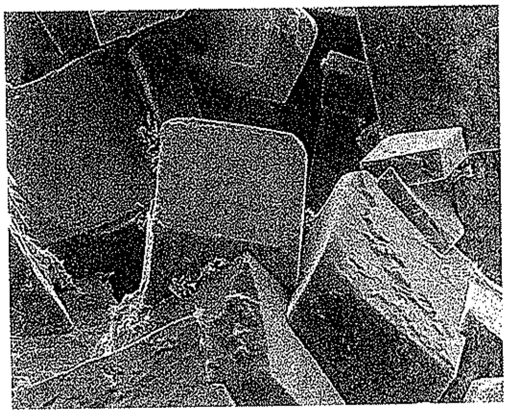
If you let go of a balloon that you've held pinched at the neck, most of the gas inside rushes out, causing the balloon to shoot through the air. Gases under pressure will escape their container if possible. If there is a lot of pressure in the container, the gas can escape with a lot of force. For this reason, gases in pressurized cylinders and similar containers, like propane tanks for gas grills, can be dangerous and must be handled carefully.

**Solids have a rigid structure**

If you take an ice cube out of the freezer and put it on a table, the ice will stay there as long as it remains solid. It has the same volume and shape that it had in the ice tray. Unlike gases, a solid does not need a container to have a shape. This is because the structure of a solid is very rigid, and the particles have almost no freedom to change position. The crystals of salt in **Figure 2-12** reflect the ordered arrangement of particles in most solids. The particles are held closely together by strong attractions, yet they can still vibrate around a fixed location.

*Figure 2-12*

The particles in these crystals of salt cannot move freely like the particles in a liquid or a gas can. These crystals of sodium chloride have been magnified 840 times.



**Quick ACTIVITY**

**Kinetic Theory**

You will need water, vegetable oil, and rubbing alcohol. **SAFETY CAUTION** The alcohol is flammable and toxic.

1. Dip one index finger into the water. Dip your other index finger into the oil. Wave each finger in the air. Do your fingers feel cool? How quickly does each liquid evaporate?
2. Repeat the experiment, using water on one finger and rubbing alcohol on the other.
3. Which of the three liquids evaporates the quickest? the slowest? Which liquid cools your skin the most? the least?
4. Use the kinetic theory to explain your observations.

**Liquids take the shape of their container**

The particles of a liquid are close together, but they are not attracted to each other as strongly as they are in a solid. So the particles in a liquid have more freedom of movement. Because particles in a liquid can move randomly, liquids can spread out on their own. And because liquids and gases can spread, both are classified as *fluids*.

Liquids vary in the rate at which they spread. You know from experience that honey is thicker and flows more slowly than lemonade. This property, **viscosity**, is determined by the attraction between particles in a liquid. The stronger the attraction, the more slowly the liquid will flow, and the higher the viscosity will be.

**viscosity** the resistance of a fluid to flow

**energy** the ability to change or move matter

## Energy's Role

What sources of energy would you use if the electricity was off? You might use candles for light and batteries to power a clock. Electricity, candles, and batteries are sources of energy. So is the food you eat. Substances that release heat when they are mixed together are another source of energy. You can think of **energy** as the ability to change or move matter. In Chapter 9, you will learn how energy can be described as the ability to do work.

**Energy must be added to cause melting or evaporation**

The first major step in the process of recycling aluminum cans is to melt the aluminum. Heating solid aluminum transfers energy to the aluminum atoms. As the atoms gain energy, they vibrate faster. Eventually, they break away from their fixed positions, and the aluminum melts, becoming a liquid. Energy is required to melt aluminum or any solid because the particles must break away from their fixed positions.

You can feel the effects of an energy change when you feel a breeze after you have been perspiring. Energy from your body's molecules is transferred as heat to the water on your skin. When this transfer occurs, your body's molecules cool off and slow down, while the water molecules gain energy and move faster, as shown in **Figure 2-13.**

**Figure 2-13**
Your body's heat provides the energy for sweat to evaporate.

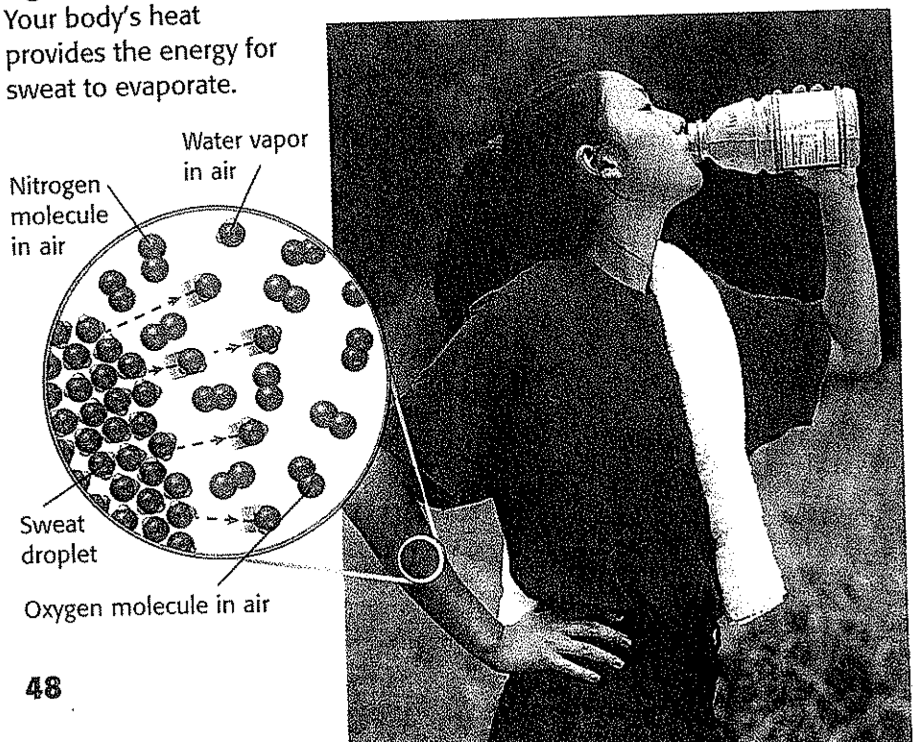
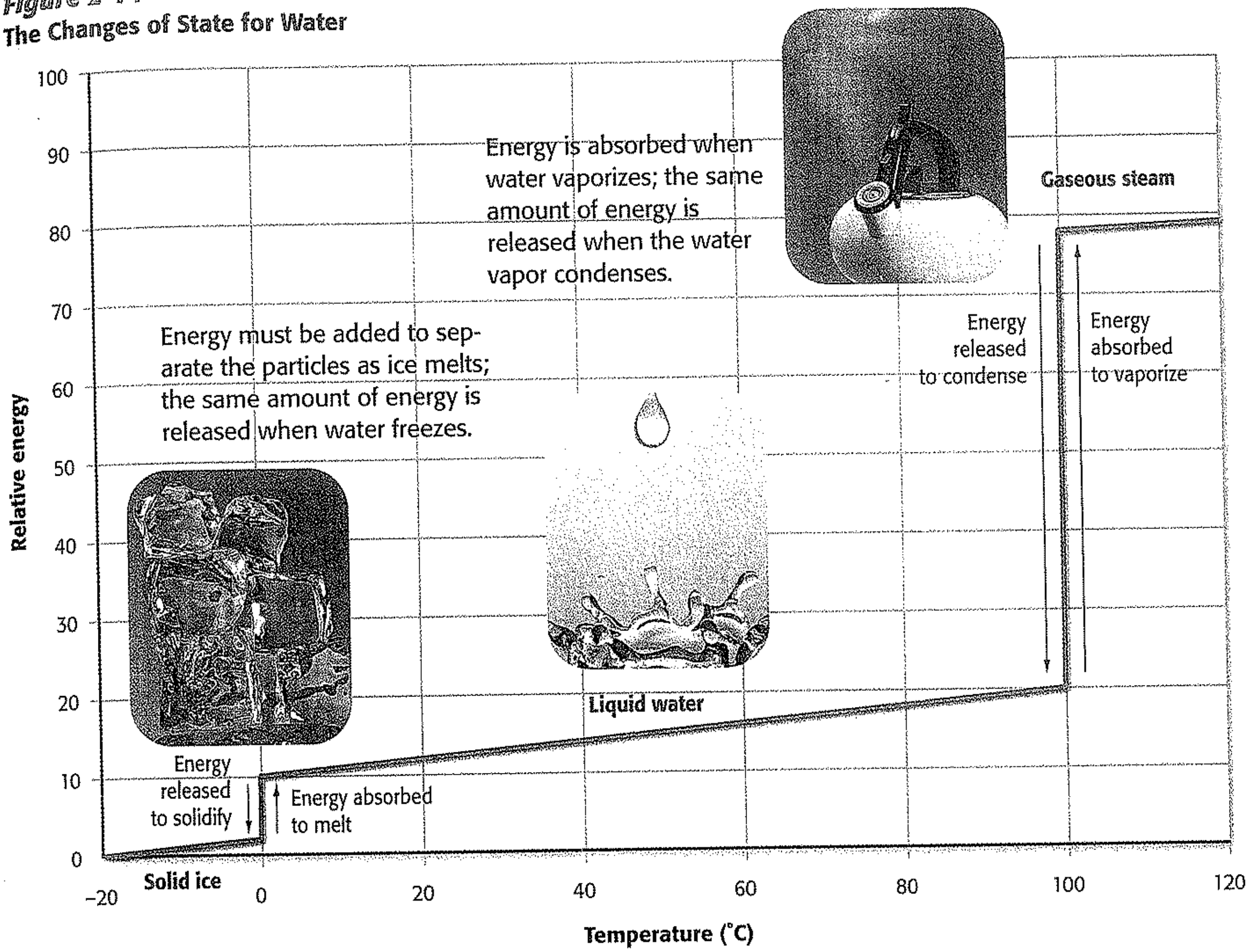


*Figure 2-14*
**The Changes of State for Water**




Eventually, the fastest moving molecules break away from the liquid surface to form a gas. The water is said to **evaporate.** It takes energy to separate the particles of a liquid to form a gas.

**evaporation** the change of a substance from a liquid to a gas

Evaporation occurs slowly when liquids are cool. But as the temperature of the liquid increases, more of the molecules gain enough energy to break away from the liquid surface and form a gas. If the liquid is heated enough, so many molecules become gas that bubbles form below the surface of the liquid and the liquid boils.

## Energy is transferred in all changes of state

When water vapor **condenses** to become a liquid or liquid water freezes to form ice, energy is transferred from the water to its surroundings. The water molecules slow down during this energy transfer. The graph in **Figure 2-14** shows the energy transfers that occur as water changes among the three common states of matter.

**condensation** the change of a substance from a gas to a liquid

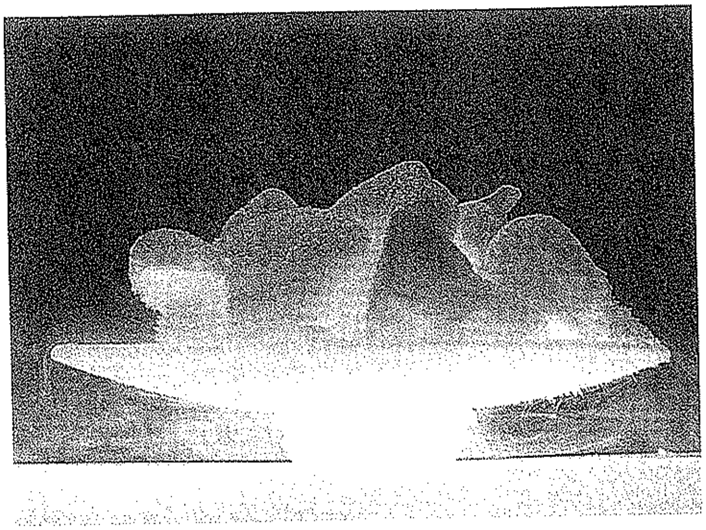


*Figure 2-15*
Dry ice (solid carbon dioxide) sublimes to form gaseous carbon dioxide but no liquid.

Some substances do not have a liquid form at normal temperature and pressure. **Figure 2-15** shows solid carbon dioxide, $CO_2$, undergoing **sublimation**, that is, turning directly into a gas without becoming a liquid. Sometimes, ice made of water molecules sublimes, forming a gas. When left in the freezer for a couple of months, ice cubes get smaller as the ice sublimes.

**sublimation** the change of a substance from a solid to a gas

## Changing state does not change composition or mass

Heating or cooling can change the state of a substance. Look at the changes of state that are happening in **Figure 2-16.** Some of the steam is condensing. As this happens, heat is transferred to the surroundings, so the steam cools and turns back into liquid water. Changing the energy of a substance can change the state of the substance, but changing energy does not change the composition of a substance. Ice, water, and steam are all made of $H_2O$ molecules. All that changes is the nature of the attractions between the molecules—strong in a solid and almost nonexistent in a gas.

When an ice cube melts, the mass of the liquid water is the same as the mass of the ice cube. Even though the ice underwent a physical change to produce the water, the mass was not increased or reduced. Similarly, when water boils, the number of water molecules stays the same even as the liquid water loses volume. The mass of the steam is the same as the mass of the liquid water that boiled off.

*Figure 2-16*
Whether it is ice, water, or steam, water in any form is always made of $H_2O$ molecules.

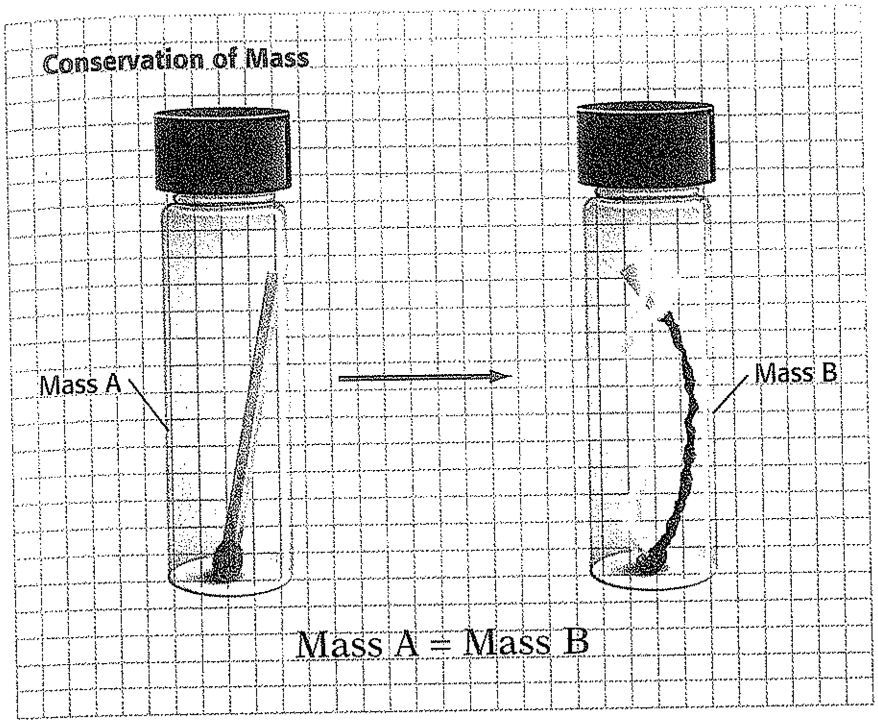



*Figure 2-17*
The match is changed by burning, but the masses of the reactants and the products are equal.

### The law of conservation of mass

In chemical changes as well as in physical changes, the total mass of all matter stays the same before and after a change. Matter changes from one form to another, but the total mass stays the same. This is called the law of conservation of mass. The law of conservation of mass is stated as follows.

**Mass cannot be created or destroyed.**

When you burn a match, it seems to lose mass. The ash has less mass than the original match. But the burning reaction involves gases too, and gases have mass, even though they may be difficult to see or measure. There is also mass in the oxygen that reacts with the match, in the tiny particles that we see as smoke, and in the gases formed in the reaction. The total mass of the reactants (match and oxygen) is the same as the total mass of the products (ash, smoke, and gases), as you can see in **Figure 2-17.**

### The law of conservation of energy

Although energy may be converted from one form to another during a physical or chemical change, the total amount of energy before and after the change is always the same. This is the law of conservation of energy, which can be stated as follows.

**Energy cannot be created or destroyed.**

The law of conservation of energy is described in more detail in Chapter 9.

**INTEGRATING**

**SPACE SCIENCE**

Studies of the chemical changes that stars and nebulae undergo are constantly adding to our knowledge. Present estimates are that hydrogen makes up more than 90 percent of the atoms in the universe and constitutes about 75 percent of the mass of the universe. Helium atoms make up most of the remainder. The total of all the other elements contributes very little to the total mass of the universe.

At first glance, starting a car may seem to violate this law. For the tiny amount of energy needed for a person to turn the key in the ignition, a lot of energy results. But the car needs gasoline to run. Gasoline releases energy when it is burned. Because of the arrangement of the atoms in the compounds that make up gasoline, gasoline has stored energy. When this stored energy is considered, the energy before you start the car is equal to the energy afterward.

When you drive a car, gasoline is burned to produce the energy needed to power the car. However, some of the energy from the gasoline is transferred to the surroundings as heat. That is why a car's engine gets hot. The total amount of energy released by the gasoline is equal to the energy used to move the car plus the energy transferred to the surroundings as heat.

When you study nuclear changes and radioactivity in Chapter 7, you will learn that the law of conservation of mass and the law of conservation of energy can be made into one law, which covers all the changes discussed here.

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## SECTION 2.2 REVIEW

### SUMMARY

- The kinetic theory assumes that all matter is made of tiny particles that are always moving.
- Solids have a fixed volume and shape.
- Gases have a variable volume and shape.
- Liquids have a fixed volume but variable shape.
- Pressure is the force exerted on the unit area of a surface.
- The viscosity of a fluid is its resistance to flow.
- Energy is the ability to heat, change, or move matter.
- Mass and energy are conserved in all changes.

### CHECK YOUR UNDERSTANDING

1. **Define** *energy*.
2. **State** the law of conservation of mass and the law of conservation of energy.
3. **List** two examples for each of the three common states of matter.
4. **Rank** the following in order of increasing strength of forces between molecules:
   **a.** honey **b.** marble **c.** water **d.** candle wax **e.** nitrogen gas
5. **Compare and Contrast** the shape and volume of solids, liquids, and gases.
6. **Predict** which two of the following involve the same energy transfer. Assume that the same substance and the same mass is involved in all four processes.
   **a.** melting **b.** evaporation **c.** sublimation **d.** condensation
7. **Describe** the energy transfers that occur when ice melts and water vapor condenses to form liquid water. Portray each state of matter and the change of state, using a computer-drawing program. COMPUTER SKILL
8. **Creative Thinking** Describe a characteristic of gases, and use the kinetic theory to explain how a dog could find you by your scent.